NAG8-1195 - amended to
NCC8-26 MSFC NASA Jove

NEURAL NETWORK BURST PRESSURE PREDICTION IN GRAPHITE/EPOXY PRESSURE VESSELS FROM ACOUSTIC EMISSION AMPLITUDE DATA

by Eric v. K. Hill*, James L. Walker II†, and Ginger H. Rowell‡

Abstract

Acoustic emission (AE) data were taken during hydroproof for three sets of ASTM standard 5.75 inch diameter filament wound graphite/epoxy bottles. All three sets of bottles had the same design and were wound from the same graphite fiber; the only difference was in the epoxies used. Two of the epoxies had similar mechanical properties, and because the acoustic properties of materials are a function of their stiffnesses, it was thought that the AE data from the two sets might also be similar; however, this was not the case. Therefore, the three resin types were categorized using dummy variables, which allowed the prediction of burst pressures all three sets of bottles using a single neural network.

Three bottles from each set were used to train the network. The resin category, the AE amplitude distribution data taken up to 25% of the expected burst pressure, and the actual burst pressures were used as inputs. Architecturally, the network consisted of a forty-three neuron input layer (a single categorical variable defining the resin type plus forty-two continuous variables for the AE amplitude frequencies), a fifteen neuron hidden layer for mapping, and a single output neuron for burst pressure prediction.

The network trained on all three bottle sets was able to predict burst pressures in the remaining bottles with a worst case error of + 6.59%, slightly greater than the desired goal of ± 5%. This larger than desired error was due to poor resolution in the amplitude data for the third bottle set. When the third set of bottles was eliminated from consideration, only four hidden layer neurons were necessary to generate a worst case prediction error of - 3.43%, well within the desired goal.

Keywords: Acoustic emission, amplitude distribution, backpropagation, burst pressure prediction, failure mechanism, graphite/epoxy, neural network, nondestructive evaluation, pressure vessel

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National Aeronautics and
Space Administration

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Subject: Grant NAG8-1195, Supplement 1

Enclosed is a copy of Grant NAG8-1195, Supplement 1, which was executed unilaterally by the NASA/MSFC Grant Officer.

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Questions relative to this correspondence should be addressed to GP54-G/Cynthia Mabry, telephone 205-544-2523, e-mail address cynthia.mabry@msfc.nasa.gov.

Mark R. Stiles
Grant Officer

Enclosure

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Space Administration

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Mark R. Stiles
Grant Officer

Enclosure

Supplement #1 for NA.E. Hill on! Supplement #2 will be the 93-94 NASA budget!

NASA National Aeronautics and Space Administration

Cooperative Agreement

NASA USE ONLY
PURCHASE REQUEST NO. 1-3-DS-00711 (1F)
APPROPRIATION SYMBOL 803/40108
PPC ST

George C. Marshall Space Flight Center

Marshall Space Flight Center, AL 35812

The National Aeronautics and Space Administration hereby awards Cooperative Agreement:

No. NAG8-273 corrected to read NCC8-26 on this Supplement No. 1 to NCC8-26 in the amount of $ 41,272

to *(Name and address of Institution)* Embry-Riddle Aeronautical University
School of Graduate Studies and Research
VC: 18926 Daytona Beach, FL 32114-3900

for *(Title)* "NASA/University Joint Venture Program"

under the direction of *(Principal Investigator)*

for a period of approximately 4 months beginning about MAY 21 1993

The NASA Technical Officer for this Cooperative Agreement is:

Dr. Frank Six
(Name)

DS01
(Address)

205-544-0997
(Phone)

Accounting Data:
323-16-02-M900-DS-3-004-000-2511 $41,272

Grant Negotiator: Sandra Presnell
Telephone: 205-544-0318 Code: AP29-D

Grant Administrator: Chrissa Hall
Telephone: 205-544-5468 Code: AP29-J

This Cooperative Agreement is awarded to support basic scientific research pursuant to P.L. 97-258(31 U.S.C. 6301, et seq.)and will be administered in accordance with the "*NASA Provisions for Research Grants and Cooperative Agreements*," attached hereto and incorporated herein, and in conformity with any appended "*Special Conditions*" or other written understandings between NASA and the recipient relating to this Cooperative Agreement. Negotiated Pursuant to the Authority of 31 U.S.C. 6304. This is a continuing award. Total amount of cooperative agreement, including all supplements, is $197,833.

ACCEPTANCE	THE UNITED STATES OF AMERICA
By Jeffery Ledewitz 5/24/93 *(Signature)* *(Date)*	Lydia Z. Van Wagner MAY 21 1993 0304 *(Signature)* *(Date)*
Jeffery Ledewitz, Ed.D. *(Typed name)*	Lydia Z. Van Wagner *(Typed name)*
Executive Vice President *(Title)*	Grants Officer *(Title)*
Embry-Riddle Aeronautical University *(Institution)*	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Center for Aviation/Aerospace Research

September 12, 1995

Maury Estes
JOVE Program Office DS 01
Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Reference: JOVE Augmentation Grant

Dear Mr. Ester:

Attached please find a copy of a grant request for the NASA Augmentation Grant Award entitled "Developing Burst Pressure Prediction Algorithms Using Multivariate Statistical Analysis and Neural Networks." Dr. Eric Hill is the Principal Investigator. Dr. Hill is eligible to apply for this award because he received funding in the amount of $41,272 from Marshall Space Flight Center effective May 21, 1993 - Sept. 21, 1993, and a subcontract in the amount of $15,500 for a National Science Foundation SBIR Phase I Project, effective April 5, 1994 - April 4, 1995. Copies of these award instruments are enclosed.

By way of explanation of the NASA Award, you may recall that these funds were folded into the NASA/Jove Cooperative Agreement, however, they were not part of the joint NASA/Jove effort. If you require further verification of this agreement, Sandra Presnell, NASA Grant Negotiator, (205) 544-0318 or Dr. Frank Six, NASA/Jove technical officer for the Cooperative Agreement (205) 544-0997, will be able to verify that these funds qualify as supplemental funding. If you have any further questions, please call me at (904) 226-6319.

Thank you for your consideration of this augmentation grant.

Sincerely,

Valerie Riley

Valerie Riley
Grants Administration Analyst

enclosure

cc: E. Hill
A. Ormsbee